High FAME blends (B30) in Inland Navigation—It works!

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Editors

OK Slurink
L. Besemer & M. Halters
Verlengde Poolseweg 32
4818 CL Breda, The Netherlands
Website: https://catom.nl/contact/
E-mail: info@catom.nl

AGQM Association Quality Management Biodiesel
Am Weidendamm 1A
10117 Berlin, Germany
Website: https://www.agqm-biodiesel.com/en
E-mail: info@agqm-biodiesel.de

Content

1. Introduction

This guide is intended to provide insights into how inland barges can transition to fuels with a higher proportion of renewable energy. The guide was created based on the real-world test experience of changing a ship from a conventional marine fuel without biofuel content (B0) to a B30 fuel with a mixture of 30 percent by volume biodiesel (FAME - fatty acid methyl esters) and 70 percent by volume conventional marine fuel meeting the EN 590 fuel specification. In this study, we aim to explore the practical implementation of biodiesel in the existing fuel supply infrastructure, focusing on an unmodified barge. By using biodiesel that is already utilized in European road transport, we can assess their viability for inland navigation without necessitating changes to the current fuel supply logistics. This guide is designed to assist industry stakeholders—including government officials, advisors, and barge owners—in understanding the potential of biofuels and especially biodiesel in energy transition within the existing supply chain and barge technology.

The test shows that switching from B0 to B30 is an easy opportunity for existing ships as well as for new acquisitions to help start reducing greenhouse gas (GHG) emissions from inland navigation and maritime shipping today.

The contents of this guide have been compiled with the greatest possible care. Nevertheless, no guarantee can be given for the accuracy, completeness and relevance the content provided. Use of the contents of this guide is at user's own risk.

2. Contribution of shipping transport to the reduction of greenhouse gas emissions.

Shipping transport has increased steadily worldwide in recent decades. Currently about 90 percent of the world trade is done via water shipment. Shipping has a significant impact on prosperity, climate and health. At the latest with the Paris climate agreement in 2015, the pressure on the shipping industry increased to provide an adequate contribution to achievement of the climate protection goals.

The International Maritime Organization (IMO) strengthens commits to reducing GHG emissions from international shipping. In July 2023, IMO adopted the *2023 IMO Strategy on Reduction of GHG Emissions from Ships* [1]. It envisages a reduction in carbon intensity of international shipping by at least 40% by 2030. Using sustainable fuels – such as biodiesel – is one option to reach this ambitious target.

The rapid and radical decrease of GHG emissions in the transport sector is one of the main targets of the climate and energy policies of the European Union (EU). As one part of the Fit for 55 Package of the EU, the FuelEU Maritime regulation [2] entered into force in 2023. It seeks to steer the EU maritime sector towards decarbonisation. To support the uptake of sustainable maritime fuels, the Commission proposes to limit the carbon intensity of the energy used on board ships. Accordingly, the proposal sets a fuel standard for ships and introduces requirements for the most polluting ship and puts the responsibility for compliance on the shipping company.

The Renewable Energy Directive (RED) is the legal framework for the development of clean energy across all sectors of the EU economy, supporting cooperation between EU countries towards this goal and prescribes emission reductions to the total amount of fuels delivered to the European market [3]. In line with the RED, The Netherlands and Germany have adopted several national measures such as pricing schemes to incentivise the adoption of renewable fuels. Together with the upcoming extension of the EU Emissions Trading System (ETS) to fuels (applicable to ships 5000 gross tonnage and above) delivered to the European market, low-carbon fuels such as biodiesel blends are becoming more in need for effectively and efficiently reducing emissions from fuel combustion to comply with legislation.

In the shipping industry, there is considerable underutilization of alternative fuels into the fuel system. Biodiesel is by far the most important biofuel in Europe with potential GHG savings of over 90% [4] . By using biodiesel in existing ships and fleets in blends such as B30 - or even as a pure fuel - there is an opportunity to make an active contribution to climate protection and significantly reduce GHG emissions already today. In addition to the potential of GHG reduction, the use of biodiesel can help to reduce the particulate matter (PM) in the exhaust gas and is a practically sulphur-free and easily biodegradable (Water Hazard Class - WGK 1) fuel. Due to its high flash point it is not considered a hazardous material. Biodiesel also has good lubricity characteristics that can potentially reduce wear on equipment.

3. General Fuel and Equipment Overview

3.1 Fuel quality and fuel supply

The quality of the diesel fuel and the biodiesel is crucial when marine engines are operated with pure biodiesel or biodiesel blends. The requirements for biodiesel as a neat fuel or as a blend component are specified via EN 14214 across Europe. For high biodiesel fuel blends like B30 there are existing fuel specifications from the automotive industry (EN 16709) and maritime industry ISO 8217:2024 that define 3 distillate and 7 residual fuel qualities with biodiesel proportion.

Before refuelling with a new fuel, the requirements and the field of application should be considered in detail. Should the fuel simply be a blend of two defined standardized fuel types - e.g. a blend of diesel fuel (acc. to EN 590) and biodiesel (acc. to EN 14214) - or should a standardized fuel be used - e.g. B30 (acc. to EN 16709)? Are there any special requirements regarding the sulphur content? Other considerations such as seasonal conditions for determining the appropriate cloud point and cold filter plugging point and how long is storage in the ship's tank likely to be are also critical considerations to determine before selecting a biodiesel supply source.

Table *1* provides an overview of selected requirements of some fuel grades that should be taken into consideration and that were used in the Project Pouwel S.

Table 1: Overview of selected parameters and standards.

Name	Method	Unit	EN 14214 (B100)	EN 16709 (B30)	EN 590 (B0)
FAME content	EN 14103	% (m/m)	Min. 96,5	Min. 24,0 Max. 30,0	0
Density at 15 °C	ISO 12185	kg/m³	Min. 860 Max. 900	Min. 825 Max. 865	Min. 825 Max. 845
Kinematic viscosity at 40 °C	EN ISO 3104	mm²/s	Min. 3,500 Max. 5,00	Min. 2,000 Max. 4,650	Min. 2,000 Max. 4,500
Flash point	ISO 3679	°C	Min. 101	Over 55,0	Over 55,0
Oxidation stability	EN 15751	h	Min. 8	Min. 20	Min. 20
Acid number	EN 14104	mg KOH/g	Max. 0,50	-	-
Polyunsaturated methyl esters	EN 15779	% (m/m)	Max. 1,00	-	-
Free Glycerol	EN 14105	% (m/m)	Max. 0,02	-	-
Water content	EN ISO 12937	% (m/m)	Max. 0,050	Max. 0,029	Max. 0,020
Sulfur	EN ISO 20846	mg/kg	Max. 10,0	Max. 10,0	Max. 10,0
Group I metals (Na+K)	EN 14538	mg/kg	Max. 5,0	-	-
Group II metals (Ca+Mg)	EN 14538	mg/kg	Max. 5,0	-	-
Phosphorus content	EN 14107	mg/kg	Max. 4,0	-	-
Cold Filter Plugging Point (CFPP)	EN 116	°C	Depending on the climate conditions and the season		
Cloud Point (CP)	ISO 3015	°C			
Saturated Monoglycerides	EN 17057	mg/kg	To be reported – see recommendations in the text		

If a fuel quality has been agreed upon, in addition to purchasing neat biodiesel or B30 according to the specification, it should be ensured to receive a current Certificate of Analysis (CoA) for each supply and that the biodiesel is already additized with oxidation stabilizers during the production process. Fuel analysis reports or bunker delivery notes should also be checked for compliance with the expected fuel specification. For marine applications, it is strongly recommended that the oxidation stability, water content and sediment parameters are within the standard limits or better.

Most engine manufacturers recommend using fuels whose suppliers and producers have monitored quality assurance systems.

3.2 Engine and Materials

Before and after switching to a new fuel the engine and fuel supply system, the fuel and engine oil filter as well as the exhaust gas aftertreatment system if present must be checked.

3.2.1 Approval of the Engine

The first and general question is if the diesel engine is approved for the chosen fuel (biodiesel or biodiesel blend). A contact to the engine/ship manufacturer is in any case useful (see 3.3 Contact to Engine/Ship manufacturer). The approval can be inherent or a special agreement between the ship owner and the manufacturer.

3.2.2. Material compatibility

If the equipment has a general B30 approval, there is sufficient certainty that all materials used are also compatible with biodiesel.

If there is no approval, it is recommended at minimum to check that the installed sealings, tank materials and water separators, if any, are suitable for B30 (or higher) fuel. In particular, the fuel feed pump membrane should be checked for biodiesel suitability. Brass, zinc, and bronze parts are to be avoided if possible, as non-ferrous metals can react with biodiesel.

3.2.3 Filters and deposits

Before transitioning to B30 fuel, it's important to consider the period of operation on B0. This interim period varies depending on usage from several months to years. Fossil fuels most likely has led to deposits in tanks & fuel systems. The biodiesel in the B30 has solvent properties that may remove these deposits. Therefore, at first the removal of these deposits formed during B0 usage might lead to filter blocking. During changeover, if specific hardware remains unchanged, there's a potential for increased deposits in the filter system due to disruption from the old setup. Thus, it's imperative to conduct thorough checks after a short running time after the transitioning to B30, especially focusing on filter conditions.

Consequently, a filter change may become necessary. If a filter change is already planned, strategically timing it after a period of short B30 running time can maximize efficiency and effectiveness.

3.3 Contact to Engine/Ship manufacturer

The suitability of a particular engine design to combust biofuels should be confirmed by the engine designer, who will typically issue generic guidance or provide specific acceptance of a particular biofuel.

For blends of biodiesel above 7%, it is recommended to get a confirmation from the engine/ship manufacturer on the suitability of the engines and engine system to burn the proposed biodiesel blend or pure biodiesel and if there are applicable conditions to the biodiesel use. Any limitations or requirements for application on board are to be followed.

3.4 Emissions

The use of fuels with a higher proportion of biodiesel blends or pure biodiesel can have an effect on ship's emissions. The higher the proportion of biodiesel, the lower are the engine-out emissions of particulate matter (PM), carbon monoxide (CO) and total hydrocarbon (THC), for example. At the same time, nitrogen oxide engine emissions (NO_x) may be increased.

Operation on distillate fuels containing up to seven percent biodiesel is already permitted and would not require NO_x recertification or any onboard NO_x emissions measurements to be undertaken for engines already certified to Regulation 13 [5]. For blends between 7-30 percent biodiesel an assessment of NO_x impacts is not required under the provisions of MEPC.1/Circ.795/Rev.8 [6].

3.5 Dealing with B30 onboard

The owner/operator should develop an implementation plan, or similar, for the use of the new fuel blends and change-over requirements in its Safety Management System (SMS). The plan needs not be submitted for approval but may be treated as part of the International Safety Management (ISM) SMS documentation in place. Unless detailed requirements are published by IMO, the 2020 guidance under MEPC.1/Circ.878 may be used as a template for developing a biofuel implementation plan.

The ship crew should be familiar with the fuels, and any required fuel changeover procedures or guidance (e.g., implementation plans) should be available and implemented.

3.6 Fuel storage stability and cold properties

When storing fuel and propellants, and thus also biodiesel, the common rules of "good housekeeping" included in the guide of good system maintenance – CEN/TR 153671 must be observed. Research projects have shown that the long-term stability of B100 under good storage conditions and with sufficient addition/stabilization can be more than six months, and in the case of B20 mixtures many years. [7][8] When high biodiesel blends are stored, it is necessary to be aware of biodiesel production quality. The most important quality parameters for B30 storage include oxidation stability and water content.

3.6.1 Oxidation stability

The addition of appropriate stabilizer additives to biodiesel usually takes place in the production process and is necessary for safe storage to achieve the minimum required oxidation stability of 8 hours (biodiesel, B100, according to EN 14214) or 20 hours (B30 acc. to EN 16709). If storage is to be carried out over a longer period, it is reasonable to increase the stability beyond the required minimum or to increase the additive amount the fuel using an additional treatment of stability additive or by introducing fresh fuel to the mix periodically.

3.6.2 Water content

The hygroscopic properties of biodiesel lead to the fact that during storage, biodiesel and biodiesel blends can hold more dissolved water than B0. Pure biodiesel can physically dissolve up to 0.150% (m/m) of water at standard conditions (EN 14214: water content max. 0.050% (m/m)) [9]. For biodiesel blends, as with all fuels, a free aqueous phase (or free water layer) can be formed when fuel temperatures drop below the filling temperature. Free water in any fuel - including B0 - can lead to corrosion and allows the growth of microorganisms, which in turn create biofilms.

Before filling with any fuel, tanks should be as clean and dry as possible. The use of a water separator between the fuel tank and the engine can also be considered. In general, it must be ensured during storage that contamination, in particular the introduction of water into the product, can be excluded by appropriate measures.

3.6.3 Cold properties

The cold properties play a decisive role, as they determine the functionality of fuels under different temperature conditions. Adaptation to seasonal requirements is essential, with a keen focus on optimizing performance during winter months.

Key parameters to consider are the Cloud Point (CP) and the Cold Filter Plugging Point (CFPP), suggesting the lowest temperature at which fuel can flow through a standardized filter. For winter applications, a CFPP of at least -10 °C, or lower, is recommended.

Beyond CFPP, several additional parameters merit attention. Saturated monoglycerides (SMG), for instance, influence fuel viscosity and stability, directly impacting filterability and overall system efficiency. Based on independently performed biodiesel tests, the AGQM recommends not to exceed an SMG level of 320 mg/l for B30, which corresponds to a maximum SMG content of approximately 1200 mg/kg in the B100 blending component. The Pour Point (PP), indicating the temperature at which fuel transitions from a liquid to a solid state, should also be at least -10 C. By adhering to appropriate pour point specifications, fuel systems can operate smoothly in cold environments. Furthermore, steryl glycosides, although less commonly discussed, are another minor component in some biodiesel supplies that can significantly affect fuel filterability of biodiesel blends.

4. Pouwel S Trial

In response to the need to decarbonize the transport sector, including inland navigation, a decisive shift towards sustainable fuel alternatives has emerged. Based on this, a trial of a fuel with a high biodiesel content in inland navigation was started in September 2023 by Catom and Slurink. For this trial, one of the engines on the barge Pouwel S was switched to a B30 fuel while a second engine on the barge continued to run on B0.

B30 fuel, a fossil fuel with an admixture of 30% (V/V) biodiesel, was chosen because it is compatible with the existing legal framework, as no additional emission measurements or legal requirements over and above those for fossil diesel fuel are required. In addition, B30 benefits from a standardized definition within established fuel standards such as EN 16709 and ISO 8217, giving it familiarity and credibility in the maritime industry.

The Pouwel S is equipped with two diesel engines. For the project, the stuurboord (STB Starboard) engine runs on fossil B0 diesel fuel, while the bakbord (BB - portside) engine was powered by B30 diesel fuel. This dual-engine setup allows the Pouwel S to live compare conventional and biodiesel fuels. The engine running on B0 diesel fuel provides the baseline comparison. Meanwhile, the engine utilizing B30 diesel fuel represents a commitment to sustainability and environmental responsibility and to show that operation with B30 provides opportunities to decarbonize barges today.

This trial, started with the Pouwel S, is a decisive step toward reducing emissions and promoting sustainable practices in the European inland shipping industry. Based on this trial, this guide shows that a changeover is easily achievable for other ships.

4.1 Experience and results

The following results summarize the experience of transitioning a ship from a conventional marine fuel without biofuel content (B0) to a B30. The findings are intended to show how a change from B0 to B30 is possible for existing ships as well as for new ships.

Before the conversion of ship operation from B0 to B30, various preliminary investigations were carried out, e.g. on the compatibility of the ship technology and materials used, and fuel requirements were defined (See Section 3: General Fuel and Equipment Overview).

4.2 Fuel analysis

As part of the Powel S Trial, monthly analyses of the B30 fuels used were carried out to monitor the quality of the actual fuel used, to identify potential contamination problems, and to determine whether the fuel deteriorates critically during operation. This was intended to ensure reliable engine operation and possibly detect problems in advance. Three different B30 fuels were used during the project. All were produced by mixing diesel fuel without biodiesel content in accordance with EN 590 and 30% (V/V) biodiesel in accordance with EN 14214. The resulting fuel was not additionally mixed with oxidation stabilisers.

Initially, a fuel was used with typical cold weather properties for the transition period with a CFPP of -6 °C and a CP of -3 °C. This was replaced in November 2023 with a B30 fuel that met the cold weather requirements of winter (CFPP: -16°C, CP: -6 °C). Before switching to the lower CFPP fuel, unexpectedly low outside temperatures led to an initial increase in fuel filter pressure. This disappeared completely after refuelling with the winter fuel. In April, the Pouwel S switched back to a B30 as at the start of the project with correspondingly higher limit values for CFPP and CP.

The starting oxidation stability of the fuels used was in range from 9,8 h to 10,9 h and showed no decrease in stability over time.

In addition to other parameters, the parameters highlighted in Table *1* that are particularly important for trouble-free operation were monitored. With a density between 843,0 and 851,5 kg/m^3, a viscosity (40 °C) between 2,946 and 3,172 mm^2/s, a cetane number over 53,6, a sulfur content below 8 mg/kg, a water content well below 0,018% (m/m) and an acid number well below 0,17 mg KOH/g the main parameters were maintained at all times in such a way that trouble-free operation was possible as with the FAME-free comparison fuel.

Overall, the analysis showed only minor influences on the fuel quality during operation and no influence of B30 over the service life. From the point of view of fuel quality and fuel consumption, there was no disadvantage to switching to B30.

4.3 Engine oil analysis

Engine oil analysis is a common practice in many industries, including inland shipping. Standard oil change interval for inland shipping engines is every 2500 hours. The oil analysis data is used to monitor for signs of abnormal engine wear, identify potential contamination issues, and determine if there is any degradation of the engine oil during use. Any one of these situations could result in less efficient engine operation or even damage to the engine which may result in downtime and other financial costs to the ship owner.

As part of the Pouwel S Trial, engine oil analysis was conducted at regular intervals to compare the engine oil analysis results of the Pouwel S – STB engine which used B0 and the oil analysis results from the Pouwel S – BB engine which used B30. The engine oil used in this trial was Castrol CRB Rivermax 15W40.

Overall, the oil analysis showed little to no impact on Kinematic Viscosity at 100°C (Figure 1) and Water Content. However, key differences between the B0 and B30 engine oil results can be noted in the change in Total Base Number (TBN) (Figure 2) of the B0 engine oil compared with the B30 engine oil and the increase in iron content (Figure 3) over time. These changes in TBN and iron content may indicate potential reduction in base available in the B0 engine oil to neutralize organic and inorganic acids that accumulate in the crankcase of diesel engines during their operation. This potentially highlights an advantage of the B30 as this reduction of TBN and increase in iron content in its respective engine oil was not observed during this trial.

Inspection via endoscopy of the two engines at the beginning of the project and in May 2024 showed no difference with regards to wear or damage between the engine using B30 compared to the engine using B0.

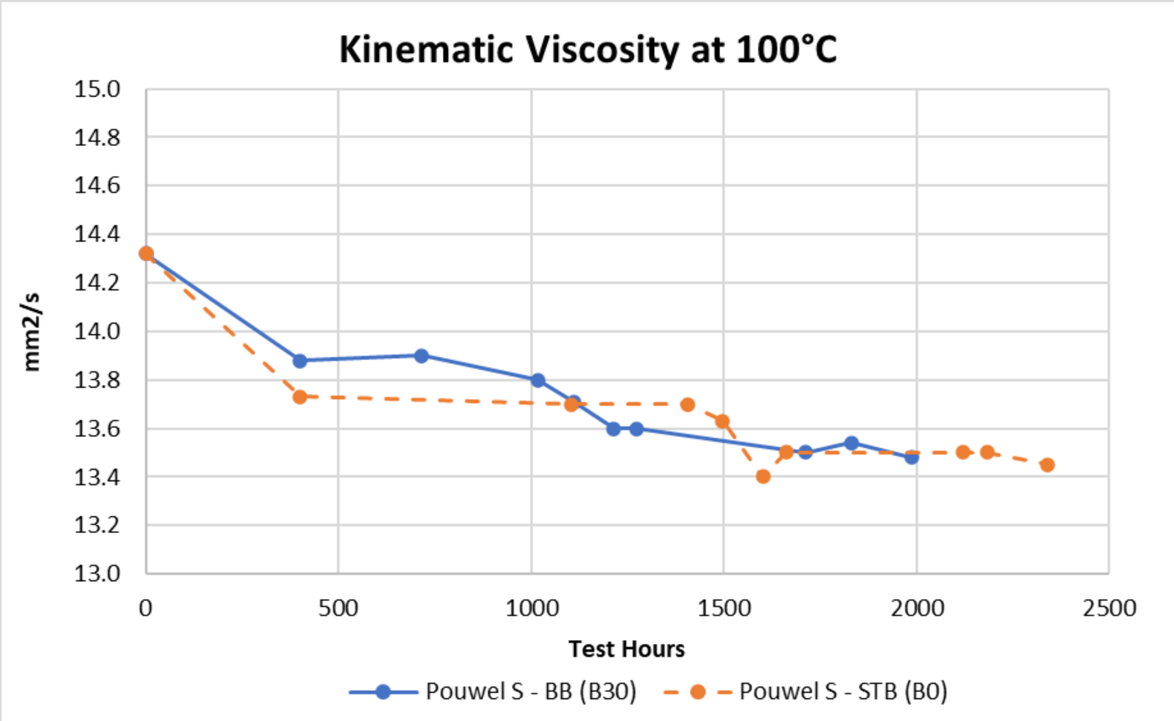

Figure 1: Comparison of B0 versus B30 impact on engine oil Kinematic Viscosity at 100°C

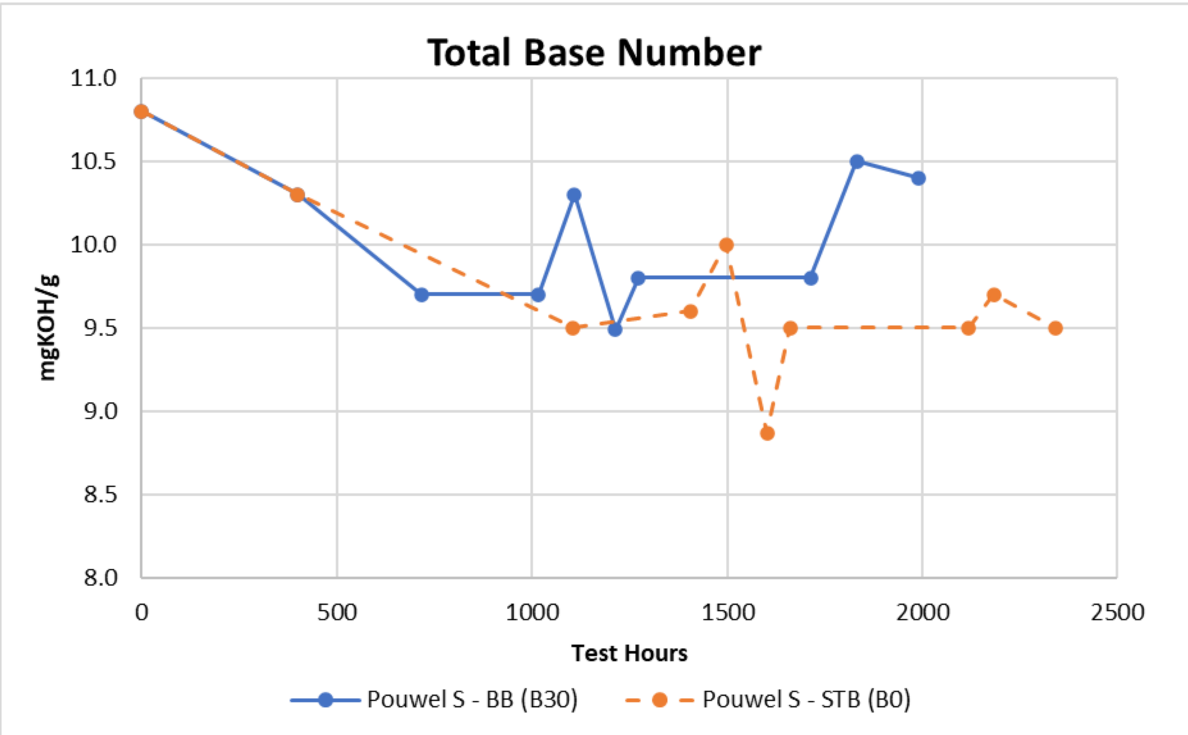

Figure 2: Comparison of B0 versus B30 impact on engine oil Total Base Number

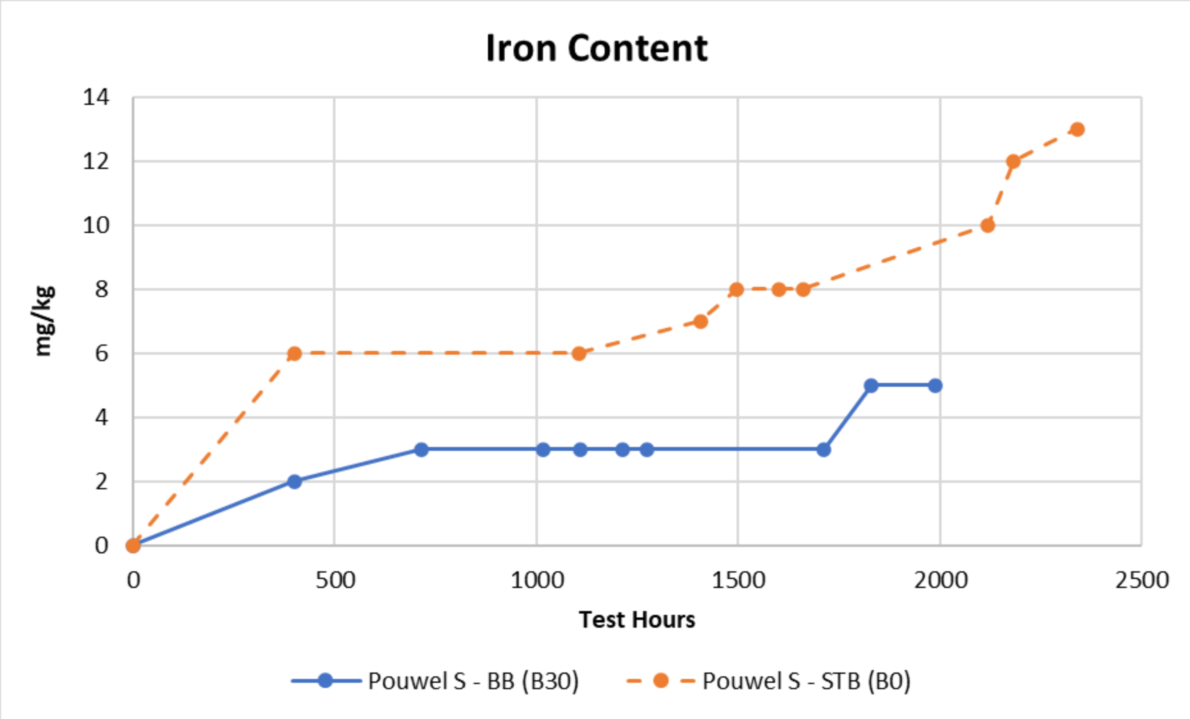

Figure 3: Comparison of B0 versus B30 impact on engine oil iron content

4.4 Operational Observations

It should be particularly emphasized that the project with the vessel Pouwel S has never encountered any operational problems. During the project, summer fuel with a high Cloud Point of -3 °C was used until well into November. The high CP led to the first signs of filter pressure increase. By switching to fuel with winter properties of CFPP < -10 °C and CP < -5 °C, these signs were resolved, and the ship was able to continue operating without any further measures.

To provide support to new users of high biodiesel blends in equipment, the contents of Table 2 have been compiled with the greatest possible care to describe potential issues and root causes for aiding in remediation of these potential events. Nevertheless, no guarantee can be given for the accuracy, completeness and relevance of the content provided. Use of the contents is at your own risk.

Table 2: Overview of operational challenges and potential root cause/action.

Observations with the use of high biodiesel blends	**Remark**
Fuel feed pump is "sweating"	Diaphragm may be not compatible with biodiesel. A replacement is necessary. Fuel feed pump can be replaced by an electric pump.
Seals on the injection pump, ball valves and fuel filters are disintegrating and causing fuel to leak out.	Seals must be replaced with biodiesel-resistant ones.
Filter blockages	Check the cold properties of the fuel and the climate conditions.

	Deposits caused using fossil diesel fuel can be loosened by the higher biodiesel content and can thus block the filter. The problem can be solved by changing the filter.
Fuel gauge defective	Plastic sensor of the fuel gauge is not biodiesel compatible and should be replaced.
Adhesions dissolve	The type of adhesives used, such as silicone bonding, is not biodiesel compatible.

5. Summary

The barge Powel S traveled for one year from September 2023 to September 2024 (over all seasons) with a fuel consisting of 30 volume percent biodiesel (FAME) and 70 volume percent fossil diesel fuel. The fuel used could be provided via the normal fuel supply system, no changes have been made to the Powel S and over the project duration no operational problems or fuel issues occurred.

Before the project was successfully implemented, various factors influencing operation with high biodiesel admixtures were examined and monitored during the project. This report summarizes the existing findings from the past and the new findings from the Powel S Trial and provides information on what should be considered when switching from pure fossil fuel to blends containing FAME.

The successful project shows that a switch from B0 to B30 is already possible today and in the existing shipping fleet without major adjustments and that in this way a significant reduction of greenhouse gases in inland shipping is possible.

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